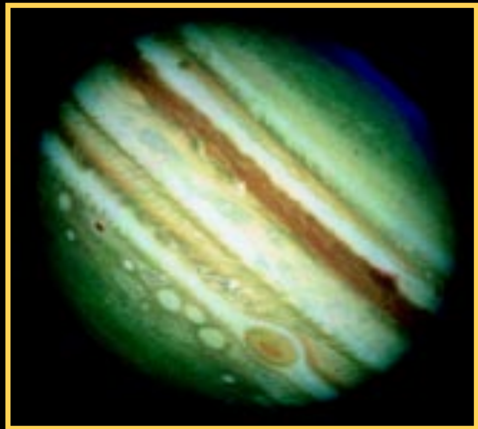
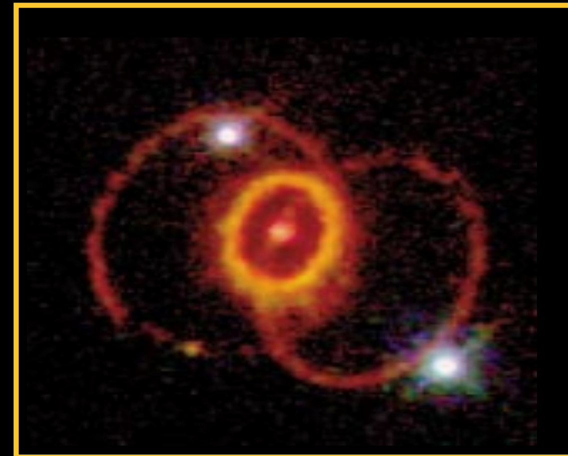
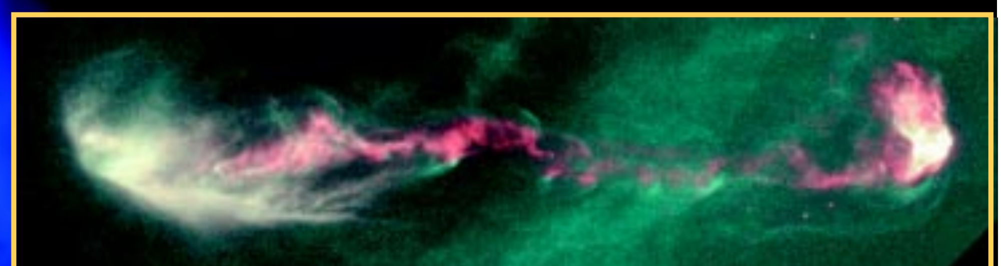




A Review of Astrophysics Experiments on Intense Lasers

Bruce Remington
Lawrence Livermore National Laboratory
41st Annual Meeting of the APS/DPP



The field of "laser astrophysics" is not new, its potential being recognized in the 1960's. Interest has been growing recently with the availability of large laser facilities.

J.M. Dawson, "On the production of plasma by giant lasers", Phys. Fluids 7, 981 (1964)

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Borovsky*et al.*, Laboratory simulation of unmagnetized SNRs," Ap. J. 280, 802 (1984)

Yu.P. Zakharov, A.M. Orishich *et al.*, SNR collisionless shock experiments with KI-1 laser (1986)

B.H. Ripin *et al.*, "Laboratory laser-produced astrophysical-like plasmas," Laser and Part. Beams 8, 183 (1990)

J. Grun *et al.*, Sedov-Taylor blast waves and Vishniac instability, Phys. Rev. Lett. 66, 2738 (1991)

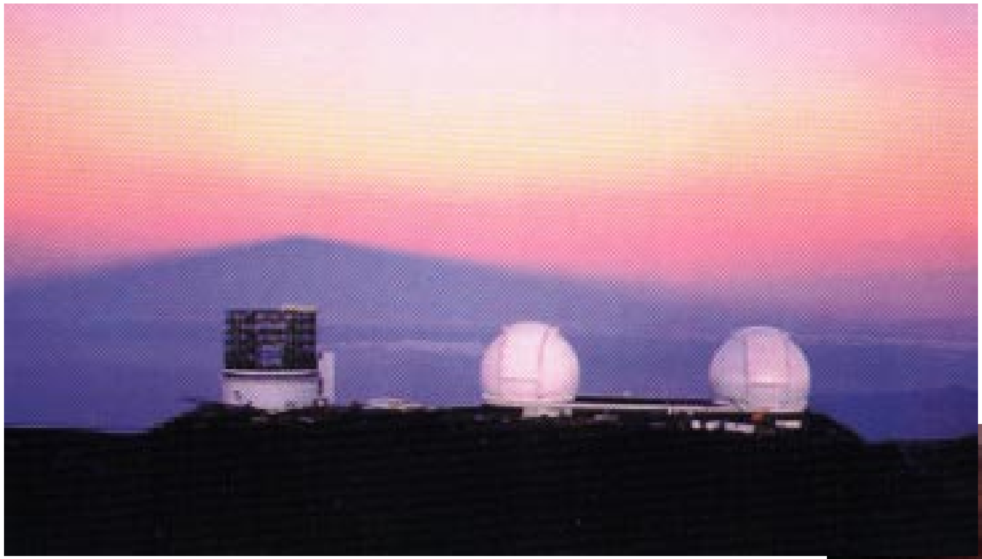
S.J. Rose, " Laser-produced plasma and astrophysics," Laser and Part. Beams 9, 869 (1991)

H. Takabe, "ICF and supernova explosions," Jpn. Plasma Fusion Res. 69, 1285 (1993)

R.P. Drake, "Laboratory experiments to simulate the hydrodynamics of supernova remnants and supernovae, J. Geophys. Res.-Space Phys. 104, 14505 (1999)

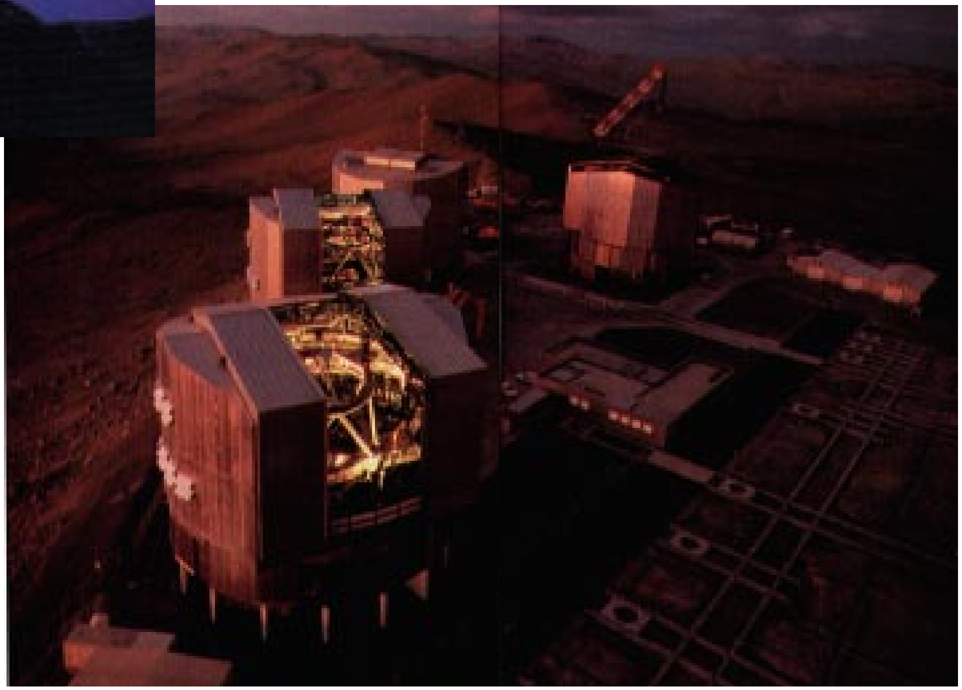
B.A. Remington *et al.*, "Modeling astrophysical phenomena in the laboratory with intense lasers," Science 284, 1488 (1999)

Astrophysics traditionally has been pursued on telescopes peering out into space from the tops of mountains, ...



Keck telescopes on Mauna Kea, Hawaii

Very Large Telescope (VLT) on Cerro Paranal in northern Chile



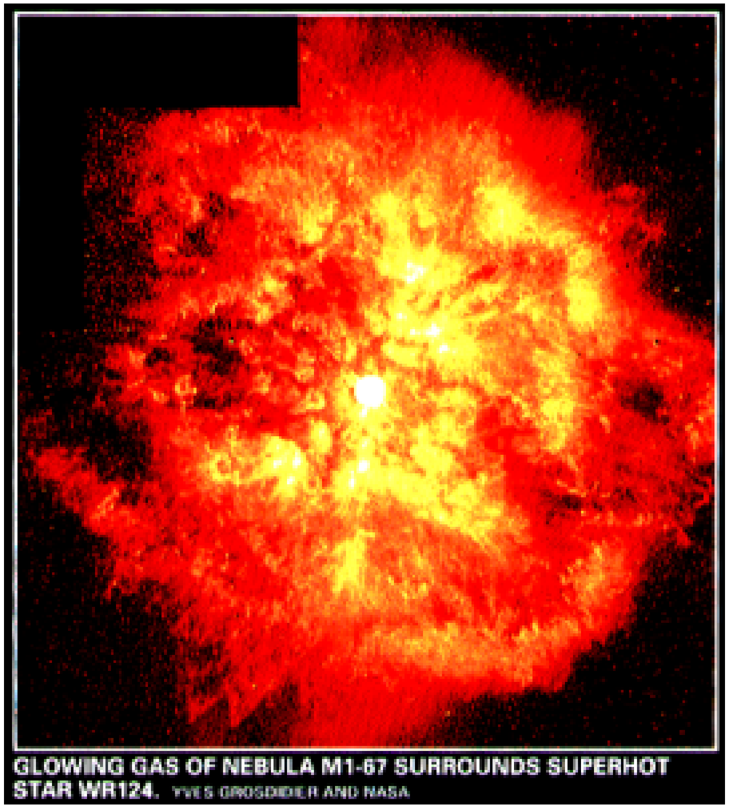
telescopes.vg

..., and from telescopes peering even deeper into space from space

HST launch, orbit.vg

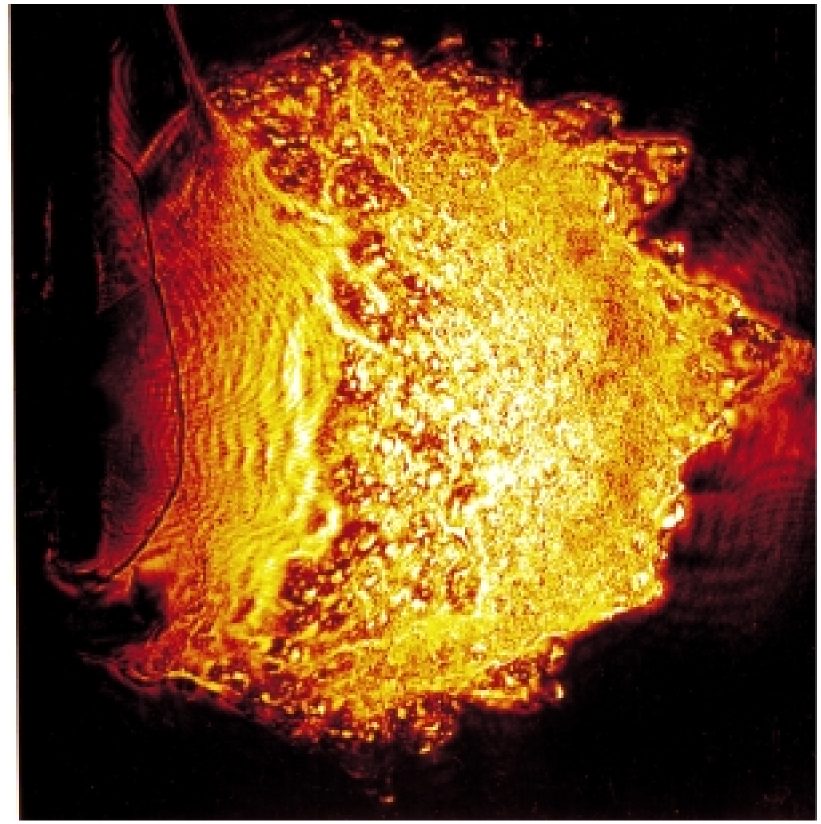
A new type of "observatory" is being developed to peer inwards

Telescope data



Grosdidier / NASA image using HST/WFPC2

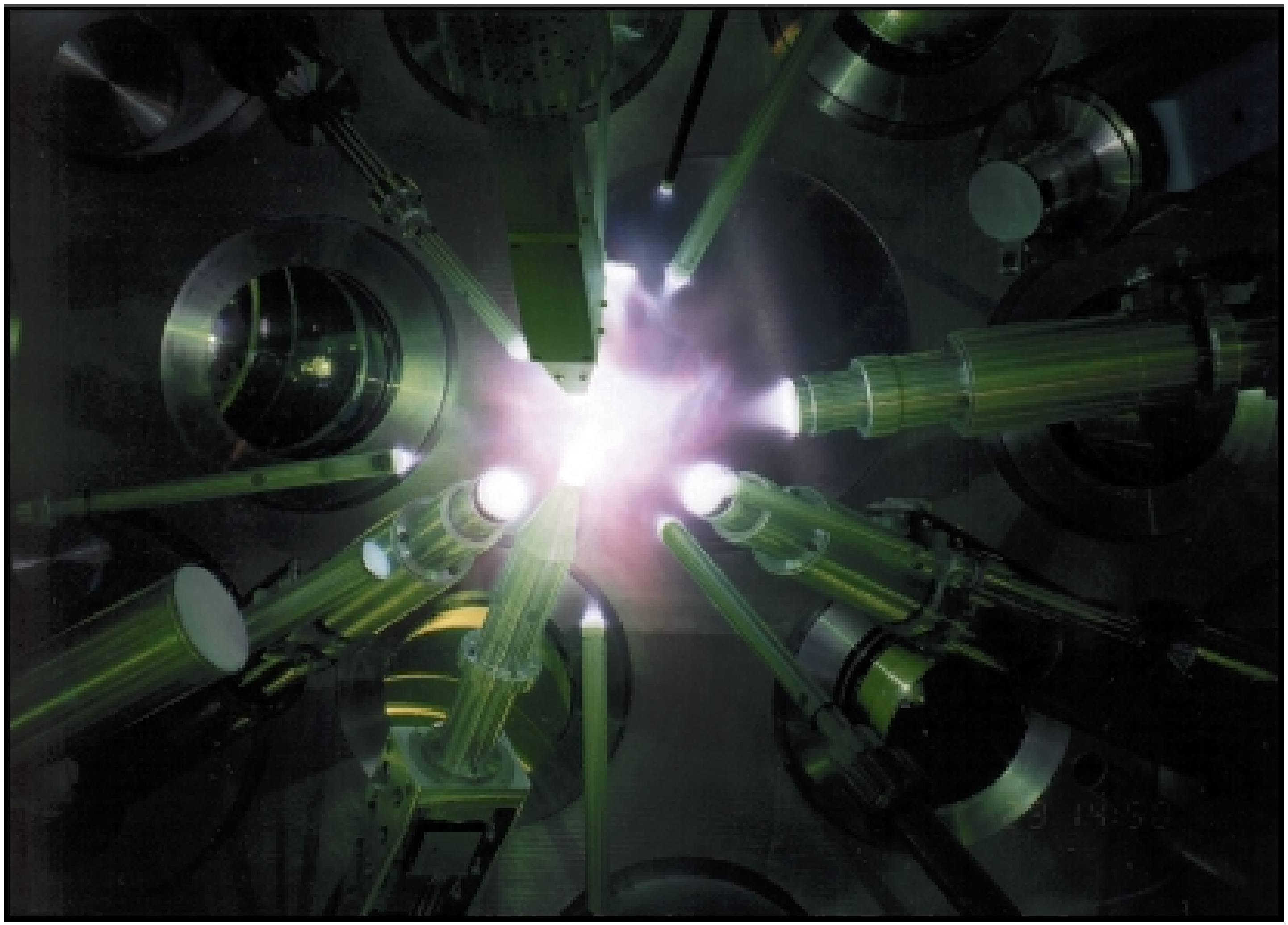
Microscope data



Grun / NRL image using Pharos laser

Grun *et al.*, Phys. Rev. Lett. 66, 2738 (1991)

Sophisticated laser facilities allow us to peer inwards at scaled astrophysical phenomena



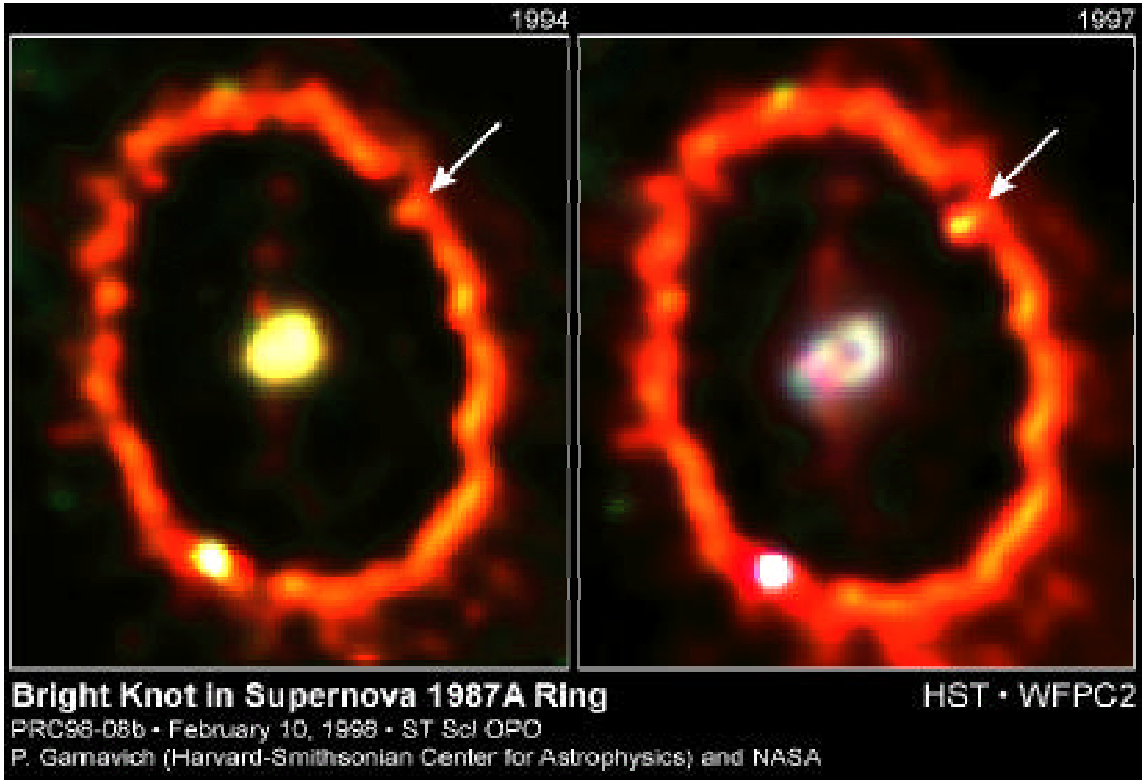
Omega laser target chamber

Characteristic spatial scales and time scales in astrophysics are long

Initial interactions of the SN1987A ejecta with its circumstellar ring nebula have been observed

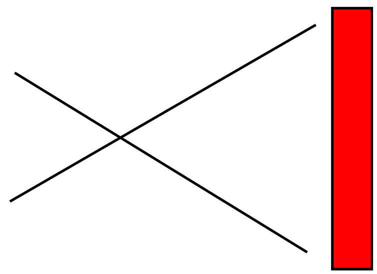
$\tau_{characteristic} = 3$ yrs

L =1 lgt yr



Characteristic spatial scales and time scales in laser experiments are short

Laser (I_L) or radiation (T_r) drive for a few x 10^{-9} s



~1 mm

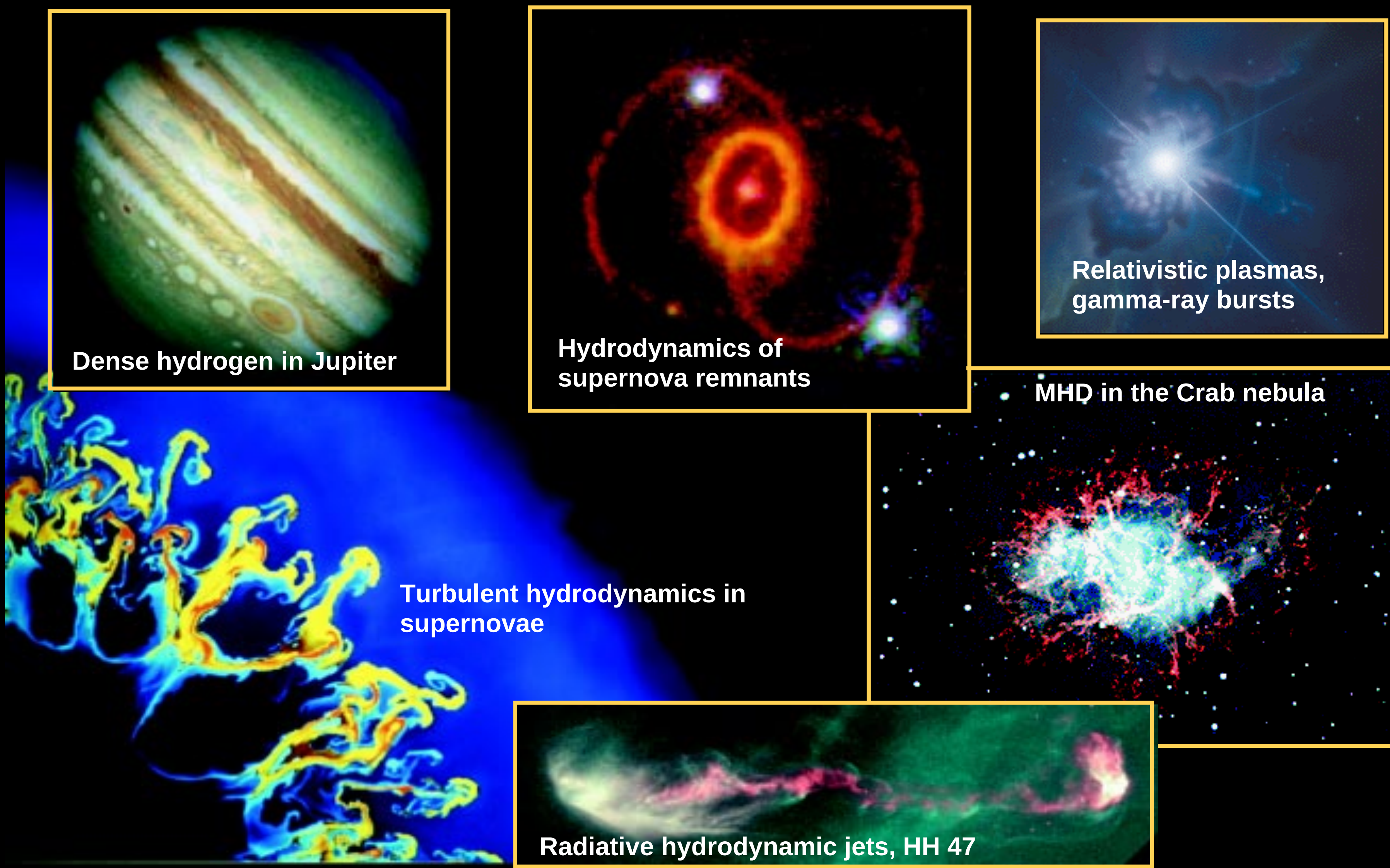
50 μm thick CH foil

Typical drive T_r = 200 eV or I_L = 5x10^{14} W/cm^2 gives P_{abl} = 30 Mbar
= 30 x 10^{12} dyne/cm^2
= 3 TP

Newtons 2nd law ($P = \rho_a\, g$) gives g = 6 x 10^{15} cm/s^2
= 60 μm/ns^2
~ $10^{13} g_0$ for a few nsec

- Pressures, shock strengths, and accelerations are large
- Dynamics are fast
- Scale transformations can connect the two regimes:
(large & slow) $\longleftrightarrow$ (small & fast)

A wide variety of astrophysics phenomena can be investigated with experiments on intense lasers



This talk will be divided into 5 generic areas, with broad applications to astrophysics

Generic area	Application
*Opacities	Cepheid variables
Radiation flow	Supernova (SN) lgt crv
*Equation of state	Giant planets
Hydrodynamics	SN explosion hydro
Relativistic plasmas	Protostellar jets
	Gamma-ray bursts

* = "input physics"
vs "output physics"